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Water and Mineral Content of an Epiphytic Fern.

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Current botanical textbooks usually say little or nothing about the inorganic constituents of epiphytes, and tend to leave the impression in the student's mind that most of these plants derive their nutriment entirely from air and rain, and therefore consist wholly of gaseous elements and carbon (whose oxides are gases).^{*} But every living organism contains protein, and every molecule of protein contains about 2% of phosphorus, none of whose compounds are vapors at ordinary temperatures, so that they are not found in the atmosphere. Furthermore, chlorophyll contains a small amount of iron, and the presence of potassium in small amounts is supposed to be necessary for the formation of starch, so that every green plant must contain some of these two metals, if not others.

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^{*}Existing knowledge about epiphytes is summarized very well in Schimper's *Plant Geography* (English edition, 1903), pp. 197-201, 317-329, and in Cowles's text-book of *Ecology* (1911), pp. 511-514, 614-616, 657-660.

The observations in this paper are intended to apply primarily to the epiphytes of temperate regions, most of which grow on the bark of trees and have no special organs for accumulating water or humus. In the tropics the epiphytic flora is much more diversified, including some plants that grow in large tufts adapted for catching falling leaves and other debris, some with concave leaf-bases that serve as reservoirs for rain-water and even as the homes of small animals, and some that grow in the axils of palm leaves, on smooth barkless trunks of palms and bamboos, or even on evergreen leaves; and some of the statements made herein would have to be modified to cover all such cases.

However, the source of supply of these non-volatile substances for epiphytes must be rather limited, and it is presumably for this reason that all epiphytes (so far as known to the writer) are evergreen. For it is obviously out of the question for an air-plant of any size to get enough solid "food" to make a complete new set of leaves every year, as most terrestrial herbs and all deciduous shrubs and trees do, and consequently such plants have leaves (or fronds or thalli in the case of some cryptogams) that last more than one year. Or the proposition might be reversed by saying that plants growing in fertile soils take up so much inorganic matter, which is deposited in leaves and other external parts by the process of transpiration, that they have to shed their leaves periodically to get rid of it.

It has been suggested that air-plants get some of their solid nutriment from dust, which is probably true; but in the heart of a vast trackless forest the quantity of dust that falls on any one herb in the course of a year must be quite infinitesimal, and there is no reason for believing that true epiphytes are less abundant in such places than near highways and habitations. Pollen of anemophilous trees is another possible source of food, just as available in a wilderness as elsewhere, but whether it contains iron and potassium or not the writer is not informed.

A much more likely source of inorganic matter for epiphytes of the type here discussed is the bark on which they grow. The bark of most trees contains 2 to 6% of mineral matter, and as it increases little in thickness with the growth of the tree it must be continually scaling off and decaying on the outside. One could with a little trouble make a rough estimate of the amount of mineral liberated in a year by a unit area of bark of a given species under normal conditions. The terrestrial herbs and deciduous shrubs that one

occasionally sees growing in the crotches of old trees must feed on bark detritus accumulated there, supplemented by a certain amount of dust, for such plants seem to be more frequent in and around settlements than far out in the woods. Falling leaves doubtless contribute a small quota too.

The most widely distributed vascular epiphyte in the United States is the little resurrection fern, *Polypodium polypodioides* (formerly known as *P. incanum*, and more recently as *Marginaria polypodioides*), which grows abundantly on living trees of various kinds from Virginia to Texas, mostly within 1000 feet of sea level. Like some other epiphytes, it is occasionally found also on non-calcareous rocks, not flat rocks on which water may stand and soil accumulate, but shaded cliffs and boulders (as in the case of its non-epiphytic northern relative, *P. vulgare*). There it has no connection with the soil (and is therefore inaccessible to earthworms, which seem to be detrimental to most evergreens), but probably gets all the nourishment it needs from decaying tree leaves that lodge around its roots. Another thing which its tree and rock habitats have in common is that they are rarely covered by snow or falling leaves; but whether that has any significance or not is not at present apparent.*

As everyone who has seen this fern alive knows, it responds readily to changes in atmospheric moisture. In dry weather the fronds shrivel up and look dead, but during and shortly after a rain, at any season of the year, they are fully expanded. The change from one condition to the other may take place in less than a day. Temperature seems to have little effect on it, except that the northern limit of the species may be determined by the minimum temperature, or the duration

* See Torrey *15*: 30-31. 1915.

of freezing weather. It seems to withstand more cold than any other vascular epiphyte in North America, however.

Just how much water it can lose and still survive is not known, but it evidently contains less than most herbs, though perhaps not less than the average evergreen herb. In March, 1919, in moderately dry weather, I gathered 13 grams of the plant in its shriveled condition, and after soaking it in water over night, until the fronds were fully expanded, and then drying off the adhering water, it weighed 30 grams, or 2.3 times as much as in the dry condition.

The total water content and ash were determined in February, as follows. On Feb. 21, about 24 hours after a rain, I gathered about 340 grams of the fern from two or three species of oaks and one of elm in and near Tuscaloosa, Ala. The fronds were then fully expanded, and presumably free from dust, though not moist to the touch. The material was weighed about half an hour later, and then chopped up to kill it, and dried for about a week, much of the time on top of a steam radiator, where a thermometer inserted in the bag of fern hay registered 46° C. or 114° F. It had then probably parted with practically all its uncombined water, for when removed from the heat it slowly gained in weight from absorption of moisture. The dry weight amounted to 42% of the fresh weight.

Fifty grams of the desiccated material, in two portions, were then thoroughly burned in a platinum crucible, and the ash weighed. One portion gave a little less than 5% of ash and the other a little more, so that we may call 5% the average. This is less than most terrestrial herbs have, but more than some. A partial analysis of the ash made for me by the chemist of the Geological Survey of Alabama, showed approximately 27% of potash and $\frac{1}{2}$ of 1% of soda, which figures are

neither very high nor very low when compared with other kinds of foliage.*

It would be interesting to try this simple experiment on other epiphytes, not only ferns, but mosses and lichens and flowering plants too, in warm climates where aerial spermatophytes are available. Possibly few botanical laboratories are provided with the requisite incinerating apparatus, but in the case of those connected with colleges there is usually a chemical laboratory near by. If the services of a competent chemist could be enlisted the ash of many such plants might be analyzed, with results not only interesting from an ecological standpoint, but perhaps also of diagnostic value in distinguishing related species.

For accurate results certain precautions should be observed, such as collecting all the material from the same tree or same kind of tree, washing off any possible dirt and dust, testing it at different seasons of the year or taking old and young foliage separately, etc. It would be a simple matter also to determine at the same time the ash content (with analysis if possible) of the bark on which the plants grow.

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Another "Freak" Equisetum

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While collecting on the southwest slope of Mount Jefferson, in Linn County, Oregon, on Aug. 13, 1919, in company with Professor M. E. Peck, we found that the delta at the east end of Pamela Lake (altitude 4000 feet) was occupied by an almost pure growth of a tall *Equisetum* with freely-branching, rather weak

* For ash determinations of several types of herbaceous vegetation on Long Island see Plant World 21: 43-46. 1918.